Telecommunications Services in the Next Decade

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Invited Paper

In this paper, the authors present their views concerning what types of telecommunications services are likely to come into existence or become widespread during the next decade. The paper is organized in terms of fundamental customer needs which those services should help to satisfy. In particular, the following categories of needs are considered: i) Information Productivity, ii) Cost-Effectiveness and Control, iii) Telemarketing, iv) Media and Protocol Conversion, v) Entertainment, and vi) Telecommunications Ubiquity. Throughout the paper, the special role of ISDN (Integrated Services Digital Network) is highlighted. It is pointed out that ISDN provides generic capabilities—a standardized digital interface, wider bandwidth, and powerful, out-of-band signaling and control—which facilitate the construction of a wide variety of new services. Finally, after discussing many potential new services in detail, the authors summarize some of the major trends which seem certain to characterize the changing face of telecommunications services in the next decade. Among these are: wider bandwidth, more data and digitization, multimedia capability, services "on demand," and internationalization. The authors also briefly discuss network-based versus CPE-based services and the likely roles of public versus private networks.

I. INTRODUCTION

Mary Jones, mother of three, walks into the study of her modern, suburban home 10 mi outside of Milwaukee, WI. After pressing a button to actuate the raising of a decorative wooden panel, she sits down in front of a built-in color-graphics terminal. An electronic voice greets her with the words, "Good afternoon, Mary. Today is Tuesday, September 28th, 1994. It is 3:07 P.M., and the current temperature in Milwaukee is 62 degrees. Skies will be clear the remainder of today with an overnight low of 44 degrees. What can we do for your today?" As the voice subsides, a menu appears on the screen, offering Mary a wide choice of functions including electronic news, catalog shopping, electronic banking, and transportation and entertainment schedules. Mary presses "talk to office," and, after entering a sequence of security codes, she downloads a copy of the "sales results" database from the mainframe computer at the corporation for which she works. Then, accessing a statistical analysis package resident on a computer at the University of Wisconsin, she attempts to verify a hypothesis concerning the impact of fluctuations in interest rates on the regional sales for which she is responsible.

While Mary is working, her 17 year old son, Jimmy, sits in front of another terminal and responds to inquiries from an interactive calculus lesson. Tiring of this, he pauses briefly to call his girl friend, Cindy. Cindy is out playing basketball, but the call is automatically transferred to a portable phone which she carries when she is away from home. To the accompaniment of razzing from her friends, Cindy explains that she cannot talk right now, but that she will call back later.

While Jimmy procrastinates over his homework, his father, David, is at his office. He is involved in a three-way, multimedia teleconference call with a colleague from New York and a stock broker in London. The broker is not on live—after all it is after 10:00 P.M. in London—but his recorded talk includes what David needs; a chart showing the hour-by-hour fluctuations of the London Stock Exchange industrial average for the day. As the call nears its end, David hears two muted beep tones, indicating that someone has left him a recorded voice message. It was Mary, and she has asked David to stop at the Food Park on the way home and pick up a quart of milk. (Mary was glad David had decided to go into the office. Usually on Tuesdays he, too, works at home via his remote terminal.)

The scenario above seems futuristic, but virtually everything included in it is possible today. What separates it from reality is not a lack of technology, but rather issues of cost, availability, and compatibility with our existing telecommunications equipment base. During the next decade, these barriers will gradually melt away. Scenarios like the one above will indeed become commonplace!

In the remainder of this paper, the authors discuss some of the wide range of telecommunications services which seem likely to come into existence or become widespread during the next decade. The organization of the article is as follows. Section II discusses "drivers" of the anticipated new wave of services; that is, the fundamental customer needs which will motivate the implementation and spread

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of new telecommunications services. With that as background, Section III touches upon the special significance of ISDN (Integrated Services Digital Network) and upon its role in meeting the fundamental customer needs described in Section II. Actual new services are discussed in Sections IV–IX, with each section focusing upon services that will help satisfy a particular one of the major customer needs identified in Section II. Finally, Section X summarizes what has been said earlier, but from a somewhat different perspective. There, the authors discuss a number of significant trends which will characterize the evolution of telecommunication services in the next decade.

II. "Drivers" of New Telecommunications Services

When one thinks about "drivers" of new telecommunications services, technology has to be at or near the top of the list. Little that is dramatically new is possible without at least some new technology, and, as is ably described in the companion paper [1] by Mr. Vickers, there will be plenty of new technology to choose from in the next decade. However, for the most part, technology determines only what is possible, not necessarily what is needed or wanted. Thus in the remainder of this section, we will focus on service drivers which stem from customer needs.

A. Information Productivity

Today, we are all besieged by ever increasing amounts of information. At offices, schools, and laboratories, the number of memoranda and articles which cross our desks, the range and extent of databases available for our use, and the number of meetings and phone calls to which we must attend seem to grow every day. In warehouses and in factories, jobs which formerly were primarily physical are now complicated by the need to maintain real-time inventories and schedules, increasingly individualized (by customer) requirements, and computerized manufacturing instructions. And, even at home, there is little respite. Personalized records keeping grows more complicated every day, a plethora of new electronic gadgets offer us new opportunities for monitoring and controlling, and the information needs and concerns of work follow us home. Much of the ever growing volume of information is potentially useful. But its sheer magnitude threatens to swamp us, raising the possibility not of progress, but of the opposite. Thus we need to become more productive in dealing with information. We must be able to access or reject, assimilate and/or store it more effectively than we do today, and telecommunications services which help to meet that need will be in great demand.

B. Cost-Effectiveness and Control

As information movement and management (IM & M) becomes a bigger and bigger part of our lives, so too does its potential expense. Thus it will not be enough to make the people that depend on IM & M more productive. At the same time, it is important to lower the cost of providing the IM & M services which are helping them. The growing importance of IM & M also implies that customers will want increasing *control* of IM & M services. They will want immediate access to those services, when they want them, and they will want to be able to tailor those services to their particular needs. Indeed, to the extent possible, many customers will want physical control over the actual equipment and facilities which are providing the IM & M services. Cost-effectiveness and control are closely related, for control implies more than just self-reliance. Control also offers the opportunity to use telecommunications equipment and services as cost-effectively as possible. Thus great demand will exist for IM & M services that improve cost-effectiveness, increase customer control, or both.

C. Telemarketing

Telemarketing can be defined as any use of telecommunications services to promote or facilitate the sale of other goods and services. For a variety of reasons, telemarketing has become a burgeoning industry during the last decade. The rapid rise in multi-job families has decreased the time available for traditional, in-store shopping. And, as a general rule, individuals have become more and more at home with all kinds of telecommunications equipment, and (perhaps sadly) less attuned to the use of written language. Thus today, many people routinely order, by phone, products which previously they might have ordered in writing or picked up at a store. Sensing the shifting pattern in consumerism, merchants have scrambled to facilitate telephone ordering and to use telecommunications service as a means of soliciting sales and differentiating their sales services. During the next decade, we can expect new telemarketing applications to intensify these trends.

D. Media and Protocol Conversion

As technology and competition have exploded in the telecommunications industry, so, too, have the range of telecommunication products, media (voice, data, image, full-motion video), and protocols (especially data protocols). To keep the associated wide array of terminals, services, and network equipment running together (or rather to minimize the number of cases when they do not), a new need has developed for media and protocol conversion capabilities. Not all such capabilities are aimed simply at mundane translations amongst slightly differing technical parameters. In particular, advances in speech recognition and speech synthesis should dramatically lower the cost of providing many new telecommunications services.

E. Entertainment

Although few consumers would actually admit it, video games have probably been responsible for more personal computer sales than any other application. In general, people have *always* been motivated to spend money on entertainment, even during depressions. Thus entertainment applications are certainly a glowing opportunity for telecommunications service providers, and that opportunity will be vigorously exploited during the next decade.

F. Telecommunications Ubiquity

As communications continue to become more and more important in our lives, we become increasingly intolerant of

circumstances which limit our ability to communicate. This simple fact has fueled the expansion of mobile, satellite, and international communications services, and it should continue to do so in the future. We should expect a continuing cycle of innovation: New telecommunications services such as data, image, and full-motion video services will be implemented first on wired or fibered domestic networks, will spread to international use, and finally, will become available as mobile telecommunications offerings.

III. The Special Role of ISDN

For several years, ISDN (Integrated Services Digital Network) has been one of the biggest topics of conversation in the telecommunications industry [2], [3]. What is ISDN and what role will ISDN play in satisfying the needs enumerated in Section II? As discussed below, ISDN is a set of capabilities which provide the *means* to implement a wide *range* of services quickly and easily. In simplest terms, ISDN is a method for providing integrated access. The "2B + D" basic rate interface provides two 64-kbit/s Bearer (B) channels, which may be used for voice, data, or image communications, and a 16-kbit/s Data (D) channel, which will carry signaling and control information and limited customer data in packetized form. Similarly, the "23B + D" primary rate interface will provide 23B channels and a 64-kbit/s D channel.

By itself, integrated access, as embodied by these two interfaces, provides new power and efficiencies. For instance, ISDN access is digital, allowing for digital services at rates up to 64, 384, or 1536 kbits/s, well in excess of the 19.2 kbits/s achievable today with analog loops and modems. Also, the D channel may be used to access packet transport services, avoiding the necessity of tying up the users' basic lines.

In addition to providing a standardized digital interface which allows access to basic voice, data, and image services, ISDN also provides a powerful, out-of-band signaling channel (D channel) that allows tying intelligence in the network to that in the user's customer premises equipment (CPE). The D channel uses message-oriented signaling (based on the CCITT ISDN signaling protocol Q.931) to provide for: a) call signaling and supervisory information, which can be used to set up or clear any switched or private line call, b) control messages, which can determine, for example, how the B channels are used, and c) the transmission of information—usually information about one or all of the parties involved in a call—between parties or between one of the parties and the network. By themselves, these capabilities do not really constitute services. However, combined with additional software in the network and/or in CPE, these capabilities can yield a wide variety of powerful new services, some of which will be described below. The *power of ISDN is that it provides* these *generic capabilities* which allow new services to be constructed with a minimum of specialized development.

Returning to the notion of service "drivers" introduced in the previous section, we can describe the special role of ISDN in a slightly different way. ISDN is a product of technology, but it is technology particularly well suited to meeting the needs represented by all the other drivers in Section II. As we shall see, all of these other drivers are served by a handful of common technological elements—wider bandwidth, digitization, and enhanced signaling and control capabilities. These are precisely the capabilities provided by ISDN, and "ISDN services" will grow as the capabilities of what we call ISDN expand. By the mid 1990s, we should see the set of standard interfaces to have expanded well beyond the current 2B + D, 23B + D, and 30B + D versions of today. Eventually, what we now call ISDN should evolve to provide integrated access and transport over pipes with total bandwidth measuring in the tens of megabits. Users' ability to control and access this bandwidth dynamically will grow in kind, leading to realization of the goal of uniform, economic availability of voice, data, and image services in any combination—"Universal Information Services" [4], [5].

IV. Information Productivity Services

It could be argued that virtually *every* new telecommunications service improves information productivity. For our purposes, however, we will consider services in four subcategories: i) call redirection and message handling, ii) teleconferencing, iii) database and information services, and iv) information monitoring and control services.

A. Call Redirection and Message Handling Services

In this section we will consider message taking and forwarding services and services involving call redirection or other forms of call handling.

1) Message Handling Services: Basic voice telephony has been widespread for many decades, and, over time, there have been impressive improvements in its quality, cost, and degree of ubiquity. Yet, technology is just beginning to solve the single biggest inefficiency associated with this service. When the called party is busy or not there, the desired passage of information does not occur. Interestingly, this is a rare area in which small business and residence customers have set the pace of progress. In these environments, telephone answering machines have become quite common, providing an opportunity for *real* communication, even if only one way.

At large business offices, where the modest cost of answering machines is certainly not a deterrent, they are generally not used. Instead, secretaries or answering services fill the breach. While the intervention of an intelligent human being would seem to be a distinct advantage, often that does not turn out to be the case. But, in general, callers refrain from asking secretaries or answering services to do much more than take down very short messages. This may be because of a fear of errors or of compromising privileged information, or it may simply reflect the knowledge that most secretaries are just too busy to take down long messages. Whatever the cause, secretaries and human answering services often act as little more than a means for initiating the next round of telephone tag.

The frustration and inefficiency associated with incompleted calls suggests that there should be a substantial market for electronic message handling services. Such services already exist in customer-premises-based systems, and relaxations of Computer Inquiry-II should pave the way for network-based offerings as well. During the next decade, services of this type should proliferate in a variety of ways:

• *Voice mail services* will save voice messages for called parties and allow calling parties to "store" recorded messages for automatic transmission or retrieval at a later time.

• *Electronic mail service* will provide for distributing typed messages to electronic "mailboxes" from which the "addressees" can retrieve them by entering a password at their terminal. The users of this service will typically be a closed community of interest groups (such as large corporations) or individual users (such as small businessmen, professionals, or residential users) who "subscribe" to the "mailed" information.

• *Electronic data interchange service* will provide message handling service for applications that involve transmission of data or graphical material: purchase orders, order status inquiries, material orders, sales results charts, etc.

Along with the basic services enumerated above, equipment vendors and service providers will offer many options which will further extend their usefulness. Such options include:

• *Broadcast capabilities*, which will allow users to input one copy of a message which will then automatically be distributed to everyone on a user supplied mailing list.

• *Password protection and encryption*, which will be available for users who require a "secure" message handling system.

• *Message waiting systems*, which will indicate whether and what kind of messages have been left.

• *"Friendly" interfaces*, which will guide the user through the necessary steps of using a service.

With time, most of these types of capabilities should become available not just for voice, data, or graphical messages, but also for image and video messages, and for messages involving combinations of these media.

2) Call Redirection/Handling Services: Call redirection services also help get at the problem of unanswered calls. Such services do and will exist in a variety of forms. Spill-over (on nonanswer) of calls to a secretary, answering machine, or answering service are elementary, existing examples. A slightly more sophisticated example involves forwarding the identity of the called party to a centralized answering location. Thus the answering operator could say, "Mr. Smith's phone," without the expensive need for Mr. Smith's line to have a parallel appearance at the operator's position. The "call-forwarding" service shown in Fig. 1, is another example of a call redirection service. Upon leaving

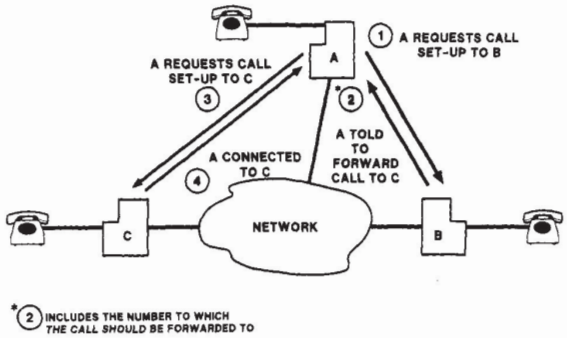

Fig. 1. Call forwarding with ISDN.

his normal answering location, a subscriber to this service punches a new telephone number into his station set. All incoming calls are then automatically transferred to that new number. Future enhancements to this service should include the ability to reprogram remotely the number to which calls are redirected, and the ability to redirect calls to mobile stations, as in the opening scenario.

Other types of call handling involve calling party identification as illustrated in Fig. 2. Selective ringing patterns may be used to identify callers by broad categories (e.g., boss, intra-office, outside line), allowing the called party to decide whether to answer or to allow the call to overflow to a message taking service. With an appropriate display capability at the called station, forwarding of the calling party number could allow the called party to determine exactly who is trying to reach him. Retention of the calling number could also allow automatic launching of a return call when the called party becomes available.

Many types of message and call handling services are already in fairly common use, and thus their inclusion in an article about *future* services could be questioned. However, they deserve mention because they seem likely to become quite widespread during the next decade. Moreover, these services are interesting because nearly all of them will be greatly facilitated by ISDN capabilities. As ISDN capabilities spread, services now available only behind a PBX will spread to far-flung corporate networks and eventually to the full universe of telephone users. (Additional examples of call handling applications will be given in Section VI, Telemarketing.)

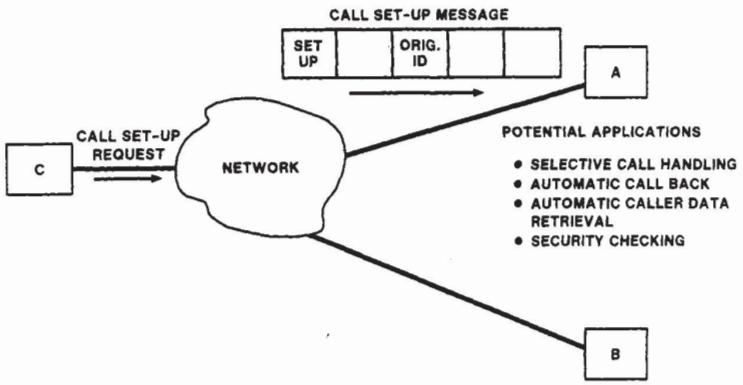

Fig. 2. Services based on station ID forwarding.

B. Teleconferencing

Teleconferencing contributes to information productivity by allowing groups of individuals to communicate without the necessity of their congregating in one location. In this section we will consider voice, video, and multimedia teleconferencing.

1) Voice Teleconferencing: It has long been possible to arrange multiparty, voice telephone conferences by making arrangements through an operator. Similarly, PBX and key-telephone users, and, more recently, subscribers to "Three-Way-Calling" service, have been able to add third parties (or, behind some modern PBXs, as many as four additional parties) to calls already in progress. Both of these capabilities have limitations—in the first case, the bother and expense of working through an operator; in the second case, the restriction of adding only one, or behind PBXs, at most a few, additional parties. Very recently, it has become possible for voice telephone users to dial-up conference calls with tens of participants. And "bridging" capabilities allow service vendors to provide "gab lines"—telephone numbers which random individuals can call to join pre-scheduled conversations on selected topics. These existing services should become widespread and routine in the next decade.

2) Video Teleconferencing: In the late 1960s and early 1970s, there were many who believed that video phones were the wave of the future. Video phones were envisioned on every corporate desk and possibly in many residences. But it did not happen.

What went wrong? For the residential market, issues of privacy aside, the service was just too expensive. For the business market, video teleconferencing was the wrong solution for the wrong problem. In theory, the service was meant to replace face-to-face meetings and save traveling expenses. Unfortunately, because high-bandwidth transport capacity was still very expensive, substantial processing was required to encode images in a format requiring 1.5-Mbit/s or less transmission capacity. This in turn made the video conference rooms very expensive, limiting their use to "exhibition" type applications or to users willing to assemble at public rooms in large cities. Moreover, because of the high cost of the transmission capacity, and/or because of the need to use public rooms, the service had to be used primarily on a reservation basis. Most important, it turned out that business people still like to meet in person, even if it means traveling.

Despite the past experience, industry watchers are again predicting a boom in video conferencing. What has changed to justify this renewed optimism? Primarily it is a matter of cost. As costs go down, video conferencing no longer needs to displace long-distance travel to be justified. It can serve close-in communities of interest, e.g., at companies with multiple locations in a small area or at universities with multiple campuses. Such users typically meet regularly, so face-to-face contact is not as critical as it is for first-time meetings. Indeed, as costs become low enough, video teleconferencing can become an *enhanced alternative* to today's ubiquitous voice-only telephone calls. Video can increase the effectiveness of these communications by adding the dimension of sight.

These new objectives of video teleconferencing are made possible by many technological advances that have been occurring in recent years. Fiber optics have driven down the cost of transmission, making even 45- and 90-Mbit/s transmissions economically viable over short enough distances. At the same time, VLSI technology and advances in coding techniques are driving down the cost and bandwidth requirements of video coders. This makes it likely that large corporations will be able to afford multiple video rooms at all their major locations worldwide. Even mobile video conferencing carts or desk top systems are a real possibility. These same video encoding technologies will give users the ability to select the technology that is most suitable for specific applications, e.g., 56-kbit/s slow-motion or freeze-frame systems for applications involving little motion, all the way up to high-resolution, full-motion systems requiring 45 Mbits/s or more of transmission bandwidth.

Finally, and perhaps most importantly, direct user control of the teleconferences via ordinary telephones and terminals, and on-demand availability of high-bandwidth transmission paths, will make video conferencing more convenient and more attractive. Together, these advances mean that video conferencing can be both reasonably economical and convenient, ensuring a significant role for such services in the next ten years.

3) Multimedia Teleconferencing Services: In addition to pure voice or pure video conferencing, today's telecommunication users also have access to facsimile and graphics transmission capabilities, and to "electronic blackboard" service. During the next decade, we can expect that all these types of capabilities will become increasingly integrated. Users should be able to shift easily from one type of medium to another, and even to mix different types of media on different legs of a conference call. For example, in the scenario of Section I, David in Milwaukee, his colleague in New York, and the broker's "database" in London were engaged in a three-way, multimedia teleconference that involved video and voice communications between the first two parties, and image (in the form of graphics) communications with the third party. David was able to set up the teleconference on demand, and to retrieve information from London interactively. He chose to obtain a graphical representation of the information he needed. However, under less urgent circumstances, the same information could have been transferred to David via facsimile or through a computer file transfer.

Why are multimedia teleconferencing services likely to be important in the future? The answer again lies in the notion of information productivity. The plethora of information with which we are all confronted exists largely in the form of text or data. But, as human beings, we learn most effectively when information is presented to us in a variety of media—voice, image and data, and various combinations of these. This is the situation which exists in face-to-face meetings and in classrooms, and this is why such forums are so important in our lives. Multimedia communications services will expand the boundaries of high "information productivity" by allowing participants in non-face-to-face meetings and learning situations to enjoy the benefits of multimedia voice, data, and image communications.

Multimedia telecommunications will show up in many guises (see Section IV-A1, Message Handling Services, as well as many of the sections ahead). The two scenarios

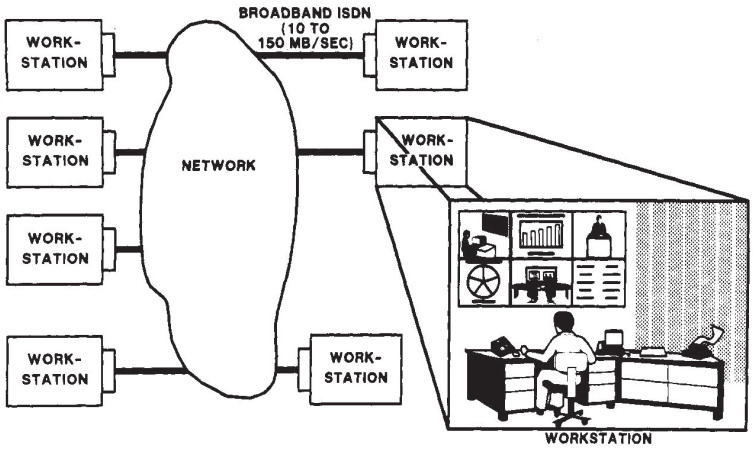

Fig. 3. Multimedia teleconferencing service.

which follow illustrate some applications which could be handled with a multimedia teleconferencing service.

Scenario 1: This scenario is representative of regularly scheduled "telemeetings" amongst employees of a multilocation corporation (Fig. 3). In it, each of the six regional sales VPs for the Acme Corporation has a workstation consisting of a high-resolution color video display with a mouse-controlled cursor, voice capabilities, a keyboard, and a phone keypad. The video displays make full use of split screens and windows selectable via the mouse, or via touch screen capabilities.

Joe Garvey, from the northwest region, initiates the conference by informing the network of the billing arrangements desired. Since each region has tightly monitored expense objectives, he specifies that the conference will share network transmission costs, but that each will pay separately for their own workstation usage. Next, Joe dials the conference participants. He could use his keypad to do this, but elects instead to activate calling instructions prestored in his workstation. Marcia Evans, the Executive VP of Sales, is added on first, followed by the regional VPs. As each participant answers, a window appears with their image, or, if no image is available, the window is imprinted with their name. Other windows are reserved for graphics, video tapes, slides, etc. Voice bridging provides equal (symmetrical), simultaneous access.

Marcia opens the meeting with a few remarks, then asks Joe to give his report on sales for the northwest region. In doing this, Joe assumes control of the video and graphics windows. Using his keyboard, or by switching screens and using his mouse-controlled cursor to select from a menu, Joe is able to access sales databases and/or pre-prepared graphics and to broadcast these to the other participants. For his finale, Joe broadcasts a video tape of the sales presentation which he used to clinch a major deal with a client in Seattle.

During Joe's presentation, each participant is able to control his or her workstation completely. The default mode zooms to Joe or to another participant when one interrupts with a question. But the default mode can be overridden, allowing each participant to select a single window permanently, all windows without zooming, or the graphics, or video window only.

Scenario 2: This scenario is representative of interactions that might take place between a corporation that designs and sells equipment and one of its suppliers. In it, Mike, who is an engineer working for a firm that develops and manufactures computer-based systems, needs some information from Doug, the representative of an electronics manufacturing company. Specifically, Mike needs information on an electronic component for use in a computer system that his company is bidding to a customer. Through a multimedia teleconferencing service, Mike places a call to Doug and explains his needs. Based on what he hears, Doug queries his own company's product database. As a result, the latest catalog information (picture of the component and descriptive information) is "windowed" on Doug's and Mike's screens. At Mike's request, Doug follows up with more information from other databases, including technical data, test performance results, pricing information, and delivery schedules. Mike stores all this information in his computer for future reference, and he and Doug make arrangements for a follow-up "telemeeting."

At the follow-up meeting, Mike describes some changes to the component that would be necessary for it to be used in the system he is developing. Doug bridges in Joe, who is a member of his company's technical support staff. Joe is able to assess the magnitude of the changes required by Mike and to provide new estimates regarding schedules and pricing. As a result of these interactions, Mike is able to complete his part of the proposal and forward it to his management.

For a variety of reasons (cost, standards, etc.) scenarios like the two above will not be commonplace even in 5 to 10 years. However, pockets of such services should develop by the late 1980s and early 1990s, primarily in large, intracompany and intra-institutional applications. When such services do develop, they will likely be based on next generation ISDN technology. Wider bandwidth will be required to support the video applications. However, the key to such services will be the type of powerful end-to-end signaling capability introduced in the original basic and primary rate ISDN implementations.

C. Database and Information Services

Today, a number of sources of data fuel the use of data communications services. Foremost among these are multi-

tudinous corporate and institutional databases containing everything from demographic and scientific data, to customer records, to inventory records, to financial records. These databases are not in themselves services. Rather, they are used by the same corporations and institutions that create them. Moving data amongst them, and between them and individual terminals, makes use of data transmission capabilities provided by public and private networks. Similarly, users of individual data terminals, facsimile machines, and other types of digital encoders "create" data which are either added to new or existing databases or simply become part of transient messages. Again, these sorts of data manipulations engender *use* of data transmission capabilities, but are not themselves services.

By a database "service" we mean a business whose objective it is to make money by charging customers for access to the information in a database maintained by the business. Today there are over 600 public databases, including ones run by well known vendors such as COMPUSERV. These are accessible by corporations or individuals via public packet data networks. In addition, many corporate networks include information databases (corporate directories, stock quotations, etc.) for their technical/management employees. And some residential information services (e.g., news, entertainment schedules, home banking services) have been made available in essentially experimental arrangements in the United States (e.g., Videotex) and especially in Europe. However, for a variety of reasons—lack of sufficient installed terminal base to support them, high transmission costs, necessity of employing limited bandwidth, etc.—usage of the database services has been relatively limited.

This situation will change! Perhaps one of the greatest revolutions in telecommunications services over the next ten to twenty years will be the spread of database services. Many factors should contribute to this change. First, continued advances in integrated circuit and fiber technology should maintain the rapid, downward trend in transmission costs while improving the cost/performance characteristics of computerized databases and the terminals which interact with them. Second, the advent of highly user-friendly, multipurpose terminals (telephone, personal computer, video/entertainment center, home/building management center), should increase the number of offices, and especially homes, that are equipped to be database service customers. Third, the increasing expense and comparative inefficiency of distributing and accessing information in hard-copy form should make electronic information services increasingly attractive. Finally, with time, society will change. A higher and higher percentage of the population will be "at home" around terminals that smack of being computers, and old notions such as that "newspapers" must come on newsprint will begin to fade away. All of these demand-side factors will then interact with the supply side, stimulating increases in the variety and quality of database services and setting in place a synergistic spread in their usage.

The growth of database services will show up in many guises. We will see the spread of electronic magazines and newspapers, and Videotex-like offerings (e.g., services like those available to Mary when she sat down at her home terminal in the scenario of Section I) should finally achieve the popularity long predicted for them. Also, for reasons like those described in Section IV-B3 (Multimedia Teleconferencing), multimedia database services should also begin to spring up. Researchers will "page" through volumes of multimedia material catalogued by subject area. Lawyers will review video "transcripts" of historic trials, and medical students will study video demonstrations of surgical techniques. Services such as these will be made possible by digitized images, with rapid screening facilitated by transmission rates in the fives and tens of megabits per second. All of these applications will be driven by the need for information productivity—the need to select from the vast array of available information and access what is wanted, when it is wanted, and in the medium desired.

D. Information Monitoring and Control Services

The final aspect of "information productivity" which we will touch upon has to do with monitoring information. It is expensive and time-consuming to monitor information if the person who needs the information must be physically present where the information is being generated. This inefficiency is compounded if the information must be monitored continually simply to respond to very occasional changes. Together, telecommunications systems and computers can often eliminate these inefficiencies. And, by allowing responses to changing information to be triggered remotely, or even by automating the triggering of those responses, even greater efficiencies can be realized.

Many telecommunications services are already based upon these simple observations, and such services should spread and expand vigorously in the next decade. Examples include:

(i) remote meter reading systems;
(ii) security and surveillance systems;
(iii) home and building management systems (e.g., control of heating, lighting, and appliances);
(iv) remote medical diagnosis and examination systems, including wide-band applications such as remote, high-resolution examination of X-rays;
(v) factory automation systems, including real-time process control and monitoring.

Many such applications involve occasional transmission of limited amounts of data. By providing a nondedicated channel (the D channel) for the control and carrying of such transmissions, and by integration of these services with other services (see, for example, Section VIII, Entertainment), the advent of ISDN should substantially promote the spread of monitoring and control services.

V. Cost-Effectiveness and Control

Technological advances are continually driving down telecommunications costs, particularly transmission, routing, and reconfiguration costs. Nevertheless, because demand for telecommunications services is rising so rapidly, it has become increasingly important to customers to control the overall amounts they spend on such services.

Closely tied to cost-effectiveness is control. By controlling *how* they use telecommunications facilities and services, customers can help control their costs. Control is also important simply because of the critical importance of telecommunications services. The more important anything

to users, the more they want to be able to control it themselves.

In order to maximize their cost-effectiveness and control, many large business customers lease private telecommunications facilities. A growing number are even willingly assuming the burden of owning and operating complete, private telecommunications networks. However, another trend should work to keep this one in balance. Powerful new software defined networks will offer customers the economy of shared, public network use, while still providing them with the control and detailed usage information which they desire.

Whether provided on private or public networks, services which offer increased cost-effectiveness and/or control should be in great demand during the next decade. In the subsections which follow, we discuss a number of services and capabilities of this type.

A. Control of How Facilities and Equipment are Used

One way to contain costs is to allow equipment and facilities to be used in multiple ways, to provide quick and economical means for shifting between those various uses, and to be able to obtain additional capacity on demand.

Examples of this include:

- *Customer-controlled reconfiguration of private lines:* The capability exists today for customers to control the usage of individual 64-kbit/s (DS0) channels in a 1.5-Mbit/s (DS1) private facility. Thus DS0 channels between Chicago and Pittsburgh can be used for voice communications between those two cities during the day, while being reconfigured as part of a data link between New York and St. Louis at night. In the future, such control should extend to cover reconfiguration of sub-DS0 channels within a DS0 circuit and of larger cross sections (DS1s) within wide-band facilities (45 Mbit/s). With ISDN, users will be able to transmit control commands and monitor their execution status over the D channel.
- *Capacity augmentation through "reserve" services:* Today, private telecommunications customers can obtain additional transport capacity, in DS1 increments, from pools of reserved circuits. Users make reservations for the use of such circuits for: a) satisfying short-duration demands such as an occasional teleconference or a regularly scheduled bulk data transfer between data centers, b) augmenting transport capacity for a relatively longer time interval such as while installing permanent facilities, and c) replacing outaged facilities in case of emergency. The reservation process today is manual, requiring intervention of an operator to receive the reservation request from the user and implement it.

In the future, users should be able to inquire directly about the availability of reserved links (DS1 or other multiples of DS0) and implement the reservation request within minutes. Furthermore, users who have private networks with customer-controlled reconfiguration (as discussed above) will be able to extend this control capability to the reserved circuit for the duration of the reservation. As for customer-controlled reconfiguration, users will be able to employ ISDN D channels for making inquiries and implementing reservation requests.

- *Call-by-call service selection:* Today, various types of special services (e.g., data channels, WATS lines, 800 lines, etc.) require dedicated links between customer premises and serving central offices. The powerful signaling capabilities in ISDN will allow individual 64-kbit/s channels in a 23B + D access link to be instantly interchanged among these various uses. In the future, similar flexibility should be available on even wider band access links.
- *Bandwidth on demand:* Another capability which will be facilitated by ISDN signaling is the ability to combine individual 64-kbit/s channels to form wider bandwidth paths. Thus on successive calls, an individual 64-kbit/s channel might be a voice path, part of a 384-kbit/s high-speed FAX connection formed by combining six 64-kbit/s channels, or even part of a video path formed by combining 24B channels. Next-generation implementations of ISDN should allow "bandwidth on demand" from multi-megabit per second pipes. From such capabilities will come the ability to support the types of complex, multimedia calls described in Section IV-B3.
- *Encryption services:* Users will be able to request encryption of calls. Information transmitted with such calls (e.g., via ISDN signaling) will indicate the corresponding type of terminal equipment required to decode them and maintain security through appropriate key administration.
- *Automatic station rearrangement:* When an employee served by an ISDN-equipped PBX or a CENTREX system changes his or her office, transmission of a simple message from the relocated station back to the network or the PBX could automatically trigger routing of telephone calls or electronic mail to the new location and/or reactivation of custom calling features.

B. More Cost-Effective Transmission Services

A very direct way to reduce telecommunications costs is simply to use lower cost transmission technology. *Packet switched data services*, already in use today, should carry more and more traffic due to their efficiency in handling "bursty" applications such as access to interactive databases. *Low-bit-rate voice and video compression* will allow increasingly economic transmission of voice, image, and video material. The "service" aspect of this will be the eventual ability for users to make quality/degree of compression cost tradeoffs. *Wide-band packet services* will provide true integration, over high-capacity channels, of voice, data, and image transmissions. Allocation of bandwidth for any communication will take place *only* when actual information is being transferred, and the distinctions between various types of transmissions (voice, data, image) will essentially disappear. The introduction of wide-band packet technology is likely to take place in two distinct phases. First, wide-band packet capabilities will be used by customers to provide as much as 5:1 "compression" (for primarily voice traffic) over dedicated channels. Later, wide-band packet technology will be used in private and public networks applications to offer a set of service capabilities such as the following:

- *Variable transmission delay* service will ensure that the information is transferred within variable time limits specified by the user. By allowing the delay to rise for some applications (such as file transfers) and ensuring minimum delay for others (e.g., interactive terminal-to-computer

access or voice transmission), users will be able to obtain increased efficiency and therefore greater cost savings. This capability could also be extended to provide a data communications store-and-forward service which would allow a customer to store files in the network and transfer them when traffic demand is at off peak.

- *Broadcast/polling capabilities* will be provided by the network when information transfers must be made to or from multiple locations. In the broadcast mode, a copy of the user's information will be sent to a "broadcast node" which will then replicate the information and distribute it to the appropriate locations. Similarly, in the polling mode, a "polling node" will retrieve the information from all the sources and assemble it for transmission to the master location.
- Users will be allowed to select *different grades of service for data transmission.* The selection may range from a block-by-block transfer, with stringent sequence and flow control (which would insure low error rates but result in a relatively slow transfer), to datagram transmission, which is less stringent but involves a lower transmission delay.

Because of the unified fashion in which all types of communications (voice, data, and image) are encoded and transmitted, wide-band packet technology should facilitate the implementation of complex, multimedia services as described in earlier sections.

C. Control of Who Uses Services and From Where

Another important element of both service control and cost control involves determining who has access to special services and from where. Both PBX-based and software-defined "private" networks already offer call screening (i.e., allowing only certain users access to special services). Such capabilities can be automatic (through identification of the calling station) or a mixture of automatic and manual, with users being required to punch in authorization codes. Similar technology is used by public network providers to control credit card calls. In the future, call screening capabilities should be extended to packet data and multimedia calls. Another trend in the future will be more flexible access to private network features from off-net locations. Thus people who are away from their offices will routinely be able to dial into their corporate networks and gain access to the corresponding special services and dialing codes.

D. Telecommunications Management Services

In the decade ahead, telecommunications managers will be provided with sophisticated, computer-based, and user-friendly systems which will integrate and automate many of their telecommunications management functions (Fig. 4). Users of private line services will have the capability to test and monitor transmission paths end-to-end (i.e., between a computer host and a terminal) and on-line (i.e., without having to suspend the transmission of data for the application itself). If a failed circuit is detected, users will be able remotely to initiate automated test systems which will sectionalize the circuit, establish loopbacks at the appropriate locations, and isolate the section of the circuit that has failed. More generally, network operators (both public and private) will be offered computer technology,

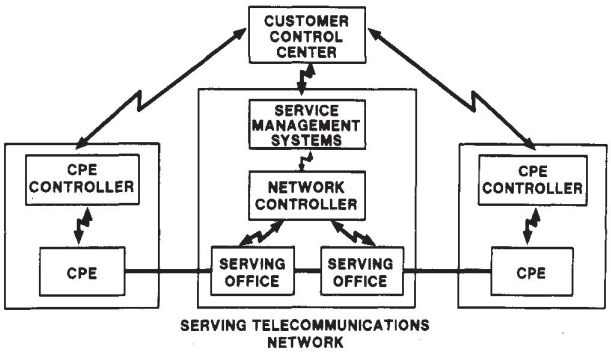

Fig. 4. Unified telecommunications management capability.

including artificial intelligence, to identify, isolate, and determine remedies for network problems. Integrated into these same systems—or perhaps existing separately—will be graphics terminals which will provide operator-friendly interfaces for all the various network control functions mentioned in earlier parts of this section and in the telemarketing section which lies ahead. Finally, network operators will gain access to increasingly flexible usage and billing statistics. This will be true for both public and private network operators, as well as for customers of "virtual," software defined networks.

Ability to control is such a fundamental customer need that virtually no new services will be offered without control capabilities being built in. Indeed, we have described associated control capabilities for many of the individual services discussed in the previous sections, and we will do the same for services discussed in sections ahead. Here we wish to emphasize the following points. First, there will be a strong trend towards centralizing control. Control of facilities, services, and even CPE will be brought together by the users at common locations via common software systems. New "services" will emerge to provide the centralization and commonality, and planning and analysis tools will be offered to achieve network "optimality" and automatic emergency reconfiguration in addition to simple control. Common standard protocols will be adopted by the industry, which will be used for control of network services and management of CPE from various vendors. Finally, ISDN signaling capabilities will play a vital role in future telecommunication management systems, both in assembling the data necessary for control and in distributing the commands that will trigger network changes.

VI. Telemarketing Services

A special type of telecommunications "need" which merits separate attention is that of telemarketing. Any telephone communication whose primary purpose is to lead to the sale of goods or services or to foster customer goodwill is a telemarketing call. Most telemarketing services involve calling from residences to businesses or *vice versa*. These services are notable because they combine businesses' willingness to pay with the massive multipliers which come when residential users are involved. And such services are propelled by a built-in economic incentive—the desire of the businesses to sell their products and services to residential customers. To discuss the telemarketing services

that are likely to surface or be enhanced in the next decade, we will distinguish two types of services: Residence-to-Business Services, and Business-to-Business Services.

A. Residence-to-Business Services

In this category we include both cases in which residential customers call businesses (e.g., 800 Service) and the converse (customer follow-up calls and phone solicitations). During the next decade, 800-like services will continue to grow and generate greater revenues. New capabilities will be added with objectives such as: i) increasing the productivity of agents who receive incoming customers calls, ii) minimizing lost calls, and iii) increasing the ease with which corporations can change the routing and handling of calls which are made to them. New capabilities of this type will take advantage of ISDN technology—e.g., using the ISDN signaling link to transmit the status of agents at multiple customer locations back to the point in the network at which call routing decisions are made.

Another area of change in 800-like services will be a widening of the types of information being provided to and from calling customers. Increased use will be made of speech recognition (to accept information from callers) and recorded or speech-synthesized (see Section VII) messages (to disseminate information or instruct callers to input more information, e.g., a credit card number). Material presented to callers will run the gamut from out-an-out advertisements to genuine informational and educational offerings. In the latter case, the calling party might share in or shoulder the cost. Finally, depending on how rapidly CRT terminals become widespread in residences, information dispensed to customers should expand from voice only to digital and image formats. Instead of just calling to make a reservation at a resort, we will be able to request a video "tour" of the rooms and grounds!

Another change in business-to-residence services will be based at least partially on ISDN-like capabilities. Telemarketing in general, including especially phone solicitation, will become much more sophisticated. Just as today we get "personalized," computer-written ads, so in the future it should not be surprising for telephone solicitors to know not only our names but other relevant facts about our families or communities. The solicitors will in turn have obtained information about us from databases, very likely via ISDN. In the opposite direction, businesses will be able to use information on the calling party's number (available via ISDN signaling) to trigger access to instant information about us, even when we call them (Fig. 2). (For example, a call to a stockbroker might trigger a display of the calling party's portfolio on the broker's CRT screen.)

Another major change in telemarketing—electronic catalog shopping—should help to drive the spread of CRT terminals into homes or provide expanded applications for family television sets. Today, with the increasing preponderance of two-worker families, catalog shopping is becoming bigger and bigger business. And, though statistics are not readily available, the bill for generating the millions of glossy catalogs which we all receive must be enormous. Thus there is an incentive for businesses to support electronic catalog ordering, and consumers would almost certainly be receptive if the cost to them is low enough and if the quality of electronic "catalog" graphics is high enough. The unanswered questions include how low is "low" cost, how good do the graphics need to be, and what will break the chicken and egg dilemma of terminal availability in homes? Will, for example, catalog vendors be able to turn their accumulated financial incentive into effective joint action? And will regulatory constraints allow them to target deployment of their services to those areas where it would be most profitable to them? Of course, there are technical questions as well, primarily concerning how low the cost of providing electronic catalog ordering can be made to go. But ten years of technical progress seems likely to make the answer "low enough". (See also discussion at end of Section IX.)

B. Business-to-Business Telemarketing Services

Many types of business-to-residence telemarketing services also apply between businesses and their suppliers. A particularly interesting example of this type is telemarketers who target customers who own or might install sophisticated premises equipment (FAX machines, personal computers, video terminals, etc.) just for the purpose of facilitating their joint business transactions. A sample application (see also Scenario 2 in Section IV-B3) might be an in-house telemarketing operation for a large drug manufacturer. Price lists, discounts in effect, product descriptions, ordering information, etc., could be contained in a corporate database. This in turn could be accessed, via a special dialing code, by large drug store chains, drug distributors, hospitals, and doctors. In an event such as the introduction of a new product, a price change, or an emergency situation (e.g., a drug recall), the information could be broadcast to a wide number of users. Such systems would support not only information exchange but also automated ordering. Applications of this type already exist and should become commonplace in the next decade.

VII. Protocol, Format, and Media Conversion Services

Rick Stevens, an account executive with Marlow Industries, stops at a phone booth along the Connecticut Turnpike. Keying in a special series of numbers, he gains access to his company's private telecommunications network. Then, by punching in seven additional numbers, he is connected to the headquarters data center in Philadelphia. A recorded announcement greets him and asks him to state his name. Rick does so, and a voice recognition system verifies that he is an authorized Marlow Industries employee. A synthesized computer voice then says, "You have been cleared for database access, Mr. Stevens," and it goes on to instruct Rick to state which database he wishes to use. Rick responds "customer records for the New England region," then attaches an acoustic coupler to the handset of the pay phone and connects it to a portable terminal/modem. He presses a "terminal ID" button, which instructs the headquarters computer to "speak" to him in ASCII asynchronous protocol. This having been accomplished, Rick is able to extract a few critical pieces of background information about the next client he is to visit. Rick chastises himself for not having brought the data with him. But he relaxes while the headquarters computer downloads a stream of additional data onto the cassette in his portable

terminal. Later, if he needs them, the additional data can be converted into a facsimile chart showing his next client's purchases of Marlow products by year and by category since 1975.

The scenario above illustrates several types of media and/or protocol conversion services—types of services which will facilitate and improve the efficiency of information transfer without altering the content of the information on an end-to-end basis (Fig. 5). *Media conversion services* will be required when users wish to: a) retrieve or access information via the media best suited for their particular application, or b) gain access to information when the CPE available to them (e.g., the pay phone that Rick used) has only limited capabilities. *Protocol conversion services* will be needed when: a) incompatible CPE from different vendors or new and old CPE must interwork to provide end-to-end service, and/or b) when protocol conversion can improve service efficiency. During the next 5–10 years, protocol, format, and media conversion services will become available either from CPE or from the network on a dedicated, reserved, or on-demand ("switched") basis. In the next two subsections we will discuss some of these kinds of services in more detail.

A. Media Conversion Services

From the user's perspective, there are two sets of applications that require media conversion services. The first set of applications deals with users' ability to retrieve information stored in a database when their user–machine interfaces range from a simple telephone set to a highly sophisticated, multimedia workstation. In this case, the information stored in the database, in the form of text or an ASCII file, must be converted to the output media selected by various users: audio output, facsimile output, teletext output, graphics or videotex output, or a combination of these. An important point about this type of application is that users' commands (i.e., inputs) to retrieve the information will be inputted through a variety of media as well: retrieval commands using push buttons on a Touch Tone telephone set, retrieval by computer or terminal keyboards, or retrieval using voice access with speech recognition.

Two forms of media conversion which deserve special attention because of their growth potential during the next decade are speech recognition (including speaker verification when needed) and speech synthesis. Speech recognition and speech synthesis are forms of user–machine (i.e., user–computerized system) interaction which will allow humans to talk to machines and receive spoken responses from such machines. The integration of speech recognition and speech synthesis with telecommunications capabilities will enable people to conduct such user–machine interactions from remote locations. Some applications which are very likely to make use of such capabilities include: credit card verification, handling of inquiries about account balances, credit card shopping, reservation making, voice control of computers, editing of text and data entry (Finally we may be able to converse with computers more rapidly than we can type!), and access to information stored in public or private databases. Many banks, credit companies, airlines, etc., already use speech recognition and speech synthesis for some applications. These applications though, especially when they involve speech recognition, are relatively simple, and task oriented—the result of current computing technology's inability to take into account context and meaning. During the next decade, advances in computing technology (higher speed, parallel processing) and artificial intelligence should lead to further progress in speech recognition and therefore make possible more complex applications.

B. Protocol and Format Conversion Services

A somewhat more mundane category of conversion services is protocol and format conversion services. Hopefully someday the need for such services will be mitigated by the availability of super intelligent terminals and networks which can "shake hands" and then "talk." However, such services are certain to be commonplace during the next decade.

1) Data Protocol Conversion and Intervention Services: Protocol conversion services include protocol conversions between ASCII Asynchronous and X.25; X.25 and X.75; Bisynch and X.25; X.25 and IBM SDLC/SNA; and between any two information "packages" protocols that deal with the routing, control, management, operation, maintenance, or

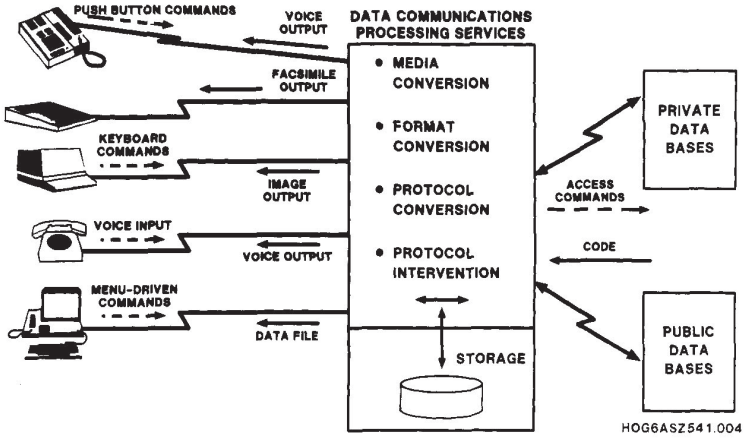

Fig. 5. Database and protocol, media, and format conversion services.

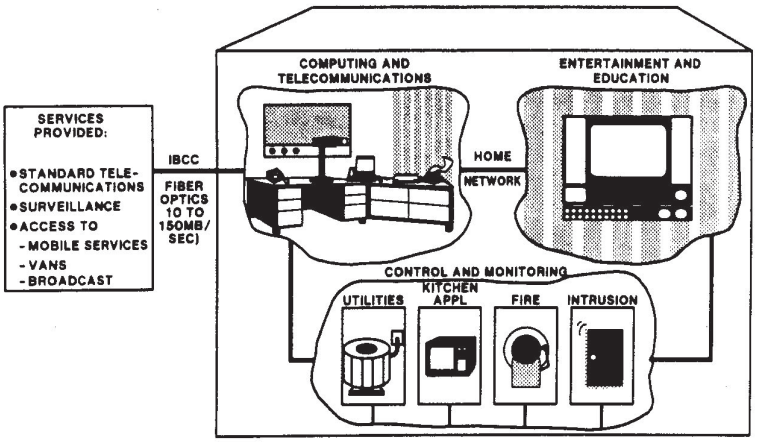

Fig. 6. Home of the future services and systems.

administration of the communications network. Such conversions may be required between terminals or services operating on the same network, or at "gateways" between networks. Complementary services that will be provided with protocol conversions include:

- Bit rate (speed) conversion for situations when, for example, a 9.6-kbit/s terminal has to communicate with a communications controller through a 56-kbit/s port, or when 9.6- and 56-kbit/s facsimile machines have to communicate with each other.
- Code conversion, such as converting ASCII Asynchronous to non-ASCII Asynchronous EBCDIC.

Protocol intervention means that the communication network interacts with the users' protocols, instead of passing them transparently, but in ways which do not alter the content of the information. A simple example is the generation of the ACK (ACKnowledge) handshake for synchronous transmission. If the ACK is generated locally in the access node rather than across the communications network, synchronous transmission is speeded up. This is important for applications in which propagation delays across the network need to be reduced.

Extending the example of eliminating "wait for ACK," it is possible to improve performance by eliminating polls being passed across the network. The remote node could be loaded with the polling list so that the node could poll the terminals independently. All data sent in response to the main frame's read/write commands would be passed on to the remote nodes. The data would be delivered to the main frame the next time it polled the specific terminal address.

2) Image Format Conversion Services: This category includes format conversions for documents, facsimile, or graphics to account for different vendors' formats or for incompatible CPE. For example, in the case of "live," revisable documents, the conversion would allow a document formatted in one system to be transferred to and to be interpreted and manipulated by a user with another system. This category also includes conversion of compound documents that include text, graphics, and perhaps even voice annotation.

3) Voice and Video Encoding Conversion Services: This category includes conversions among vice and video encoding methods such as analog to digital, and conversions among different digital encoding and compression schemes.

VIII. Entertainment Services

As indicated in Section II, entertainment applications should provide a significant opportunity for the telecommunications industry during the next decade. Early in that decade, existing telephone lines will reach widespread use in providing entertainment program subscribers with the *control mechanism* for selecting entertainment events they wish to receive (and pay for) over the broadcast media. The prime example of this is on-demand pay television, which will allow cable television subscribers to pay on a per-event rather than a flat-rate basis. Although there are many ways to implement such a service, the key elements are: i) allowing subscribers to signal to the cable television company their selection of an entertainment event and ii) providing the cable television company with the identity of the subscribers who have made selections. On the basis of this information, the cable television company can proceed with: i) activating the remotely addressable decoding boxes connected to the subscribers' television sets, and ii) initiating appropriate billing.

During the later part of the decade, the role of telecommunications services, both in entertainment and in other home functions, will begin to change drastically (Fig. 6). A single ISDN Broad-Band Communications Capability (IBCC) will replace the separate networks (e.g., broadcast and cable television, telephone radio, and control and monitoring circuitry) which provide services to the house. (See Section IV-D for more on control and monitoring services.) The broad-band link will use a single universal port at the house, instead of the many interfaces in use today (e.g., radio antenna, TV antenna, telephone box, modems, cable TV box, etc.).

Together with cheap, multipurpose terminals, IBCC will act as a catalyst for the introduction of many new services into the home. Entertainment services (e.g., interactive games, high-fidelity digital TV, music and movies on-demand) are likely to provide the broad-based demand that will lead to the deployment of broad-band residential loops and multipurpose terminals. Then, riding atop that wave will come many other services which have not become

widespread in residences on their own. Beneficiaries of this spillover effect will include videotex and home computer services (including the type of database link which Mary used in the scenario of Section I), remote educational services, and multimedia teleconferencing and telemarketing services as described in Sections IV and VI.

IX. Telecommunications Ubiquity

As we indicated in Section II, the desire for ubiquity will be a major driver for the emergence of new telecommunications services in the next decade. Telecommunications ubiquity will be promoted by services such as message handling, call forwarding, and call transfer, which were discussed in Section IV. Such services increase the likelihood of calls being "completed." Another aspect of ubiquity involves being able to call "from anywhere-to-anywhere" as shown in Fig. 7. In the next three subsections we will

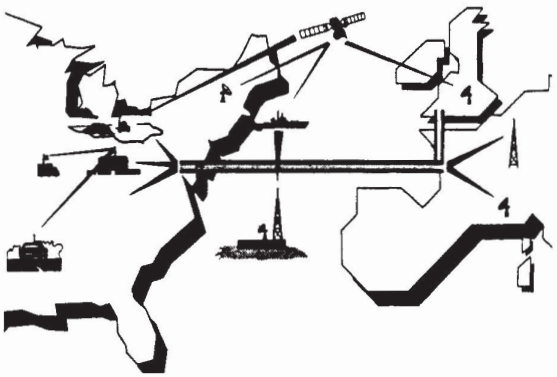

Fig. 7. Telecommunications ubiquity.

discuss three types of telecommunications services—international, satellite, and mobile services—which address this aspect of ubiquity.

A. International Telecommunications Services

During the next ten years, international telecommunications services will experience tremendous growth and diversification. Trends in this arena should follow similar trends which have taken place domestically during the last decade. Some of the factors motivating the spread of international services will be the following: i) Multinational corporate users will need and want to use services abroad that they have come to rely upon domestically; ii) The installation of new high-capacity transmission capabilities (over fiber optics or satellite facilities) will engender substantial rate reductions, making affordable services which were out of the question earlier; and iii) Much improved collaboration should emerge between international service providers and foreign PTTs, at least partly because of the potential for new customers and revenues. What specific international telecommunications services are most likely to catch on during the next decade? First of all, private line services (dedicated or obtained through a reservation system) at rates up to 2.0 Mbits/s and higher are likely to experience rapid and widespread expansion. These services will provide users with the ability to extend their private corporate networks overseas and to support new applications such as international high-speed data transmission, image transmission, and video teleconferencing. Other services which are likely to experience growth (for the same reasons as their domestic counterparts) are: international 800 and international credit card calling services; teleconferencing, both audio and video, electronic mail and voice messaging services, and international packet switching services. During the later part of the decade, the spread of ISDN capabilities throughout the world will facilitate the implementation of sophisticated international services.

B. Satellite Telecommunications Services

In recent years, the growth of satellite telecommunications has fallen short of earlier expectations. However, the next decade should witness steady growth in satellite services. What factors account for this optimistic prediction? First of all, satellite communications can cover widespread geographical areas, thus providing the most cost-effective means for reaching remote and/or sparsely populated regions. As nations and institutions strive to provide basic telecommunications services to every corner of the globe, this "thin-route" communications capability will play a crucial role. Other services based on the same capability include: satellite-based mobile telecommunications (see Section IX-C) and nonmobile links to isolated exploration platforms and research stations.

Another important advantage of satellite telecommunications is ready applicability to point-to-multipoint communications. This will continue to make satellites attractive for such applications as one-way broadcasts (video or data), multipoint teleconferencing, and some other types of private networks. In conjunction with small, rooftop *Ku*-band earth stations, the point-to-multipoint capability will provide users with an end-to-end private line solution for directly sending and receiving data between a central location (e.g., a corporate data processing center) and multiple branch locations. Last, but not least, satellite telecommunications can be rapidly deployed to meet special needs such as: i) communications support during special events, e.g., important visits by foreign personalities, worldwide concerts, etc., ii) communications at disaster sites; or iii) special, limited duration needs for extra transport capacity along an existing route.

A second reason for optimism about satellite communications is evolving new functions, which previously were associated only with terrestrial systems. These new functions include; encryption, interfacing to public packet-switched services, protocol conversion, multiplexing (e.g., time-division multiple access), and the ability for direct customer control and reservation of satellite links.

C. Mobile Telecommunications Services

Basic mobile telecommunications services such as paging, land-mobile telephone service, and residential portable telephone service have been available for many years. Yet, those services have not gained widespread acceptance by users, mainly because of their limited capabilities and performance, and high costs.

Despite this past experience, mobile telecommunications services should enjoy rapid and sustained growth in the next decade. What are the reasons for this renewed op-

timism? First, declining costs should allow mobile services to provide economic benefits greatly exceeding subscription costs and the costs of acquiring the necessary terminal equipment. Thus mobile communications will increasingly be used to send and receive signals to and from aircraft, ships, and land vehicles. Contact with those mobile vehicles during their journeys will allow them to be warned of dangerous situations or rerouted due to new business information (e.g., new orders), and it will support timely business conversations with their operators or passengers. While some of these benefits are already achievable today via short-wave radio transmissions, tie-ins to the telephone network will dramatically extend the ease and range (in terms of possible participants) of such communications.

Second, new functionality will attract new users and increase the cost-effectiveness of mobile services. For example, future cellular systems are likely to provide not just voice, but also data and image (text, telex, FAX) communications, electronic mail service, voice mail service, automatic call transfer capability, and access to audio conferencing. Other new services will emerge to satisfy additional customer needs. For example, wide-area or national paging services will be capable of providing alphanumeric message displays and store-and-forward capabilities. Satellite-based mobile communications will be used to provide services such as surveillance, interactive data and videotex, 1.5-Mbit/s voice, and even compressed video transmissions. Residential consumers will also benefit from advances in mobile and portable telephone services. Using pocket-sized mobile phones, they will be able to communicate over wide area systems while out walking, shopping, or, like Cindy in the Introduction, playing basketball.

Finally, an improving regulatory climate and sustained efforts to achieve international technology standardization should provide added impetus to the evolution of mobile communications services. Still, because of the intrinsic complexity of mobile services, their growth, both in terms of deployment and capabilities, will continue to lag far behind that of nonmobile services.

X. Concluding Remarks and Summary

A. How Far, How Fast: The True Determinants

The rate of technological advance has soared in the past few decades. However, the ability of society to assimilate that new technology has not fully kept pace. Indeed, the growing value and complexity of the existing, embedded, technological base make "rolling" that base ever more difficult. Today, we can build great highway, bridge, and sewer systems, but we can only afford to replace a small fraction of what we already have at any one time. Similarly, it is technologically possible—right now—to provide phenomenal new telecommunications services. But the reality of implementation often requires that new equipment be compatible with billions of dollars of existing telecommunications plant, much of it more than 20 or 30 years old.

Thus to be successful, potential new telecommunications services must pass a number of very stern tests. First they must offer an extremely high value/cost quotient (value being measured by the importance of the customer need satisfied); otherwise, potential customers will choose elsewhere amongst the wide array of available, technological goodies. Next, "winning" new services must offer a clear and profitable path along which implementation can proceed. If a new service requires wide deployment of expensive new equipment, then it will be hard to get that service going, even if it would sell like "hot cakes" once it were fully in place. (There are severe, chicken-and-egg dilemmas. For example, potential customers may not buy terminals because the services that would make them useful are not there, while potential service vendors shy away because of the absence of a terminal base to support them.) Finally, telecommunications services face additional obstacles not common to all technologically driven industries. Successful new telecommunications services must enjoy a supportive regulatory environment as described in the companion article [6] by J. Haring. (Witness the decade plus delay in advanced, mobile telecommunications services attributable primarily to regulatory wrangling.) Moreover, with scores of equipment vendors and growing numbers of carriers, potential new services are often delayed while international committees go deliberately about their business of creating new telecommunication standards.

In short, technology will not be the limiting factor in determining what new telecommunications services become widely available in the next decade. Technology *will* undoubtedly provide surprises. (Ten years ago, for example, how many people predicted today's ready availability of video tape recorders and laser discs?) However, the real determinants of telecommunication services in the next decade will be factors such as consumer preferences, value/cost quotients, the availability of practical implementation paths, and regulatory and network standards issues. These factors add additional layers of uncertainty that make predictions about the next 10 years precarious at best!

B. Major Trends in Telecommunications Services

Despite the uncertainties referred to above, the material in the preceding sections of this paper suggests a number of general trends which seem certain to characterize telecommunications services over the next 5–10 years. Although none of these are surprising, it is nevertheless interesting to set them down in one place and to examine how they are interrelated.

Wider Bandwidth: This is both the most obvious and the most important of all the trends discussed. Bandwidth is to telecommunication services (Fig. 8) as amperage is to electrical services—without enough of it, there are certain kinds of things which just simply cannot be done. Fortunately, high-bandwidth transport is rapidly becoming cheaper, just as is the computing power which enables the kinds of services which require that higher bandwidth. Thus

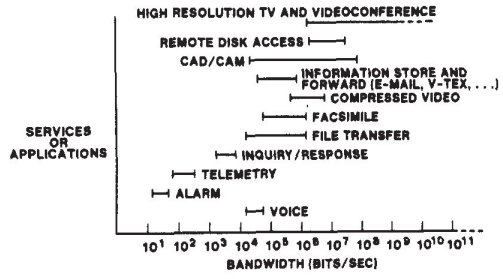

Fig. 8. Customer needs—bandwidth by service or application.

just as we have seen an explosion in the use of computer memory, so we can expect to see an explosion in bandwidth. (Indeed, the drivers in both cases are the same: lower cost of the element in question, memory or bandwidth, coupled with lower cost of the computing power which consumes it.) The one difference is that memory is deployed right alongside the computing power, so that deployment costs are not a factor. In contrast, transport bandwidth must be provided *between* computers or between computers and terminals, so that deployment costs, and the cost of the media providing the bandwidth, are significant. This is particularly true with respect to reaching low-density, residential customers. The cost of deploying access bandwidth to the residential market will be a limiting factor, just as it was originally for basic voice telephone service, and just as it is now for cable TV.

Nevertheless, the spread of high-bandwidth capability should come rapidly, even for customer access. Where not too long ago dedicated T1 (1.5-Mbit/s) access links were a status symbol, 45-, 90-Mbit/s, and even gigabit access links to large businesses should become common. These links will cary mixtures of voice, high-speed data, and video signals, with connections to both public and private networks.

The trend in the residence market will be similar, but at a slower pace and probably with lower maximum bandwidths at any point in time. The spread of high-bandwidth access links to residential customers should parallel that of cable TV. That is, it will start in densely populated and affluent suburbs and spread from there. In the meantime, new electronics, such as that associated with ISDN, will hasten the spread of new services by continuing to squeeze greater bandwidth out of existing media.

More Data, More Digitization: Data communications is the fastest growing part of the communications industry, and data traffic may make up as much as 40 percent of all traffic by the 1990s. However, a related trend, that towards digitization of all types of telecommunications traffic, may rapidly render such statistics meaningless. Already, much of the embedded long-distance network is fully digitized, and, by the mid-1990s, that digitization should be nearly complete. At the same time, new technology (e.g., ISDN technology) is moving digitization out to the customer premises. Thus by the mid-1990s, much of the total, domestic telecommunications network will carry nothing but streams of bits, indistinguishable as to whether their original source was voice, data, or image.

The trend towards digitaization is particularly important. Digitization facilitates reliable transmission, regeneration of signals, and multiplexing of different types of telecommunications together. More importantly, it enables processing—processing to achieve capabilities such as routing, bridging, prioritization, selective delay, storage, random retrieval, and encryption. These capabilities are either required for or dramatically facilitate many of the types of services described in the previous sections.

Multimedia Services: At the USTA Convention in New Orleans in February of 1985, Wayne Weeks, President of AT & T Network Systems, set forth a goal which he dubbed Universal Information Services. That goal is the "universal and economic availability of voice, data, and image services, together or in any combination." The telecommunications industry should, in fact, move steadily towards that goal, in part because of what is technologically possible. Wider bandwidth is a prerequisite for multimedia services, and digitization will facilitate and help to make such services economical. However, there has to be demand as well as capability, and the demand will stem significantly from the notion of "information productivity" discussed in Section IV.

Customer Control and Services on Demand: Another major trend, already well in progress, is that towards greater customer control. Through the magic of microprocessors, customers can forward incoming calls to new locations of their choice, reconfigure their own private line networks, redistribute 800 calls amongst several answering locations, and alter the enhanced services available at individual station locations behind a PBX. And, as we have seen, ISDN signaling will facilitate many new and more powerful forms of customer control (e.g., control over the manner in which individual 64-kbit/s access channels are employed, automatic station rearrangements behind a PBX, etc.). Capabilities such as these create a highly desirable win–win situation. Customers gain direct control over the telecommunications resources they pay for, without the expense or delay of waiting for a network provider to do the controlling for them. At the same time, network providers are freed from performing onerous "change activities," and their networks produce more revenue because customers can use them how they want to, when they want to.

Because of the powerful incentives provided by the win–win situation described above, customer control should continue to increase rapidly. Ultimately we should arrive at one of the subgoals of Universal Information Services—the ability for customers to obtain telecommunications services (and the bandwidth required to support those services) on demand, and to pay only for what they actually use. In short, today's "special services" will no longer be special.

Businesses First: For at least two major reasons, the strongest surge in new telecommunications services in the next decade is likely to be in the business arena. The first reason is willingness and ability to pay. Most potential new telecommunications services involve more efficient processing (reception or dispensing or both) of information. To businesses that means dollars, whereas, to most residential users, the result is merely convenience. Second, large businesses in particular provide substantial and highly concentrated community of interest groups. Such groups can often be serviced either by premises-based or network-based services, and concentration helps justify the cost of new equipment.

Network-Based versus CPE-Based Services: For the most part, services have been discussed in this paper without regard to whether they will be network or CPE based. The reason for this is that many types of services will be offered in both ways. Cheapter and higher bandwidth transmission will allow widely distributed processing environments. Centralized computers will perform functions (e.g., CAD/CAM, remote medical diagnostics, etc.) which require passing larger and larger quantities of data back and forth at higher and higher speeds. And, as users' terminals gain their own increased memory and processing power, larger and larger quantities of data will be passed from centralized databases to be processed at the customer's premises.

Processing power will grow in terminals, in centralized main frames, *and* in the network. Computers *in* the network will abound, not just to provide basic switching functions, but rather to perform a wide range of protocol and media conversion functions, network resource management functions, and a wide range of enhanced telecommunications services (assuming regulatory rules allow it!). In the end, it will become increasingly difficult to tell apart the computers that are running the communications network from those that are performing services via the communications path offered by the network.

Private versus Public Networks: Today, more and more large corporations are building and/or operating their own private telecommunications networks. There are several reasons why this is occuring, and why the trend will continue for some time: i) owning or operating a private network is the ultimate expression of customer control; ii) non-cost-based tariffs imposed upon public network providers enable business customers to save money by running their own networks; and iii) it is often possible to obtain new services more rapidly by relying on customer premises and/or private network-based solutions rather than on public network offerings. This is in part because public networks are often more dependent upon the slowly grinding mill of international standards bodies.

In the long run, however, the trend towards private networks seems likely to level off. Again, there are several reasons for this. First, competition and the changing regulatory climate should eventually allow most tariffs to move closer to a true-cost basis. When that occurs, the intrinsic economics of shared networks should become a bigger factor in corporate decisions. Second, declining computing costs (allowing cheap protocol and format conversion, for example) and progress in multimedia standards should diminish any feature gap between public network capabilities and those offered by private network and/or customer premises equipment. Similarly, technology should also enable customers to effectively control their communications whether they occur over public or privately owned networks. (We are already seeing these trends today in the form of new CENTREX capabilities and in virtual (software-defined) private networks.) Finally, many corporations will undoubtedly find that the joys of private network ownership fade as the realities of maintenance costs and technical obsolescence rear their ugly heads. For these reasons, today's trend towards more private networks should not be expected to continue unabated. In the mid-1990s, both public and private networks will play major roles.

Internationalization: Much has been written about the "shrinking world" and the "global community." Indeed, driven by ever cheaper transport, telecommunications services of all kinds should become increasingly internationalized. In general, though, a gap should continue to exist between the availability of new services on an intra-country basis and internationally. Technology—in the guise of message handling, protocol, and even language conversion capabilities—should help. And, an increasing trend towards accepted international telecommunication standards (witness ISDN) should also help. But additional barriers—language, time-zones, and the size of communities of interest—should always cause international services to lag behind.

Competition: Competition has become a way of life in the telecommunications industry, and it will continue to bring with it both plusses and minuses. On the one hand, it cannot help but stimulate the implementation of new services. On the other hand, until or unless networks and CPE both get to be smart enough, the multitude of equipment, network, and service providers will inevitably provide new obstacles to making everything work well together.

C. Concluding Remark

The past decade has been an exciting one in the telecommunications industry. However, from the standpoint of new services, the next decade should be even more exciting. In the previous sections of the paper, we have described a veritable host of new service possibilities. Not all of these will come to pass, and certainly not all will become widespread. But past history suggests that, in general, improvements will come even more rapidly than we have predicted. And, by the mid-1990s, some services which we cannot even imagine today will have become commonplace.

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